



# **National Polar-orbiting Operational Satellite System (NPOESS) Microwave Imager/Sounder (MIS) Capabilities**

**Pacific METSAT Working Group  
Apr 09**

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NPOESS

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MIS Chief Engineer, NPOESS

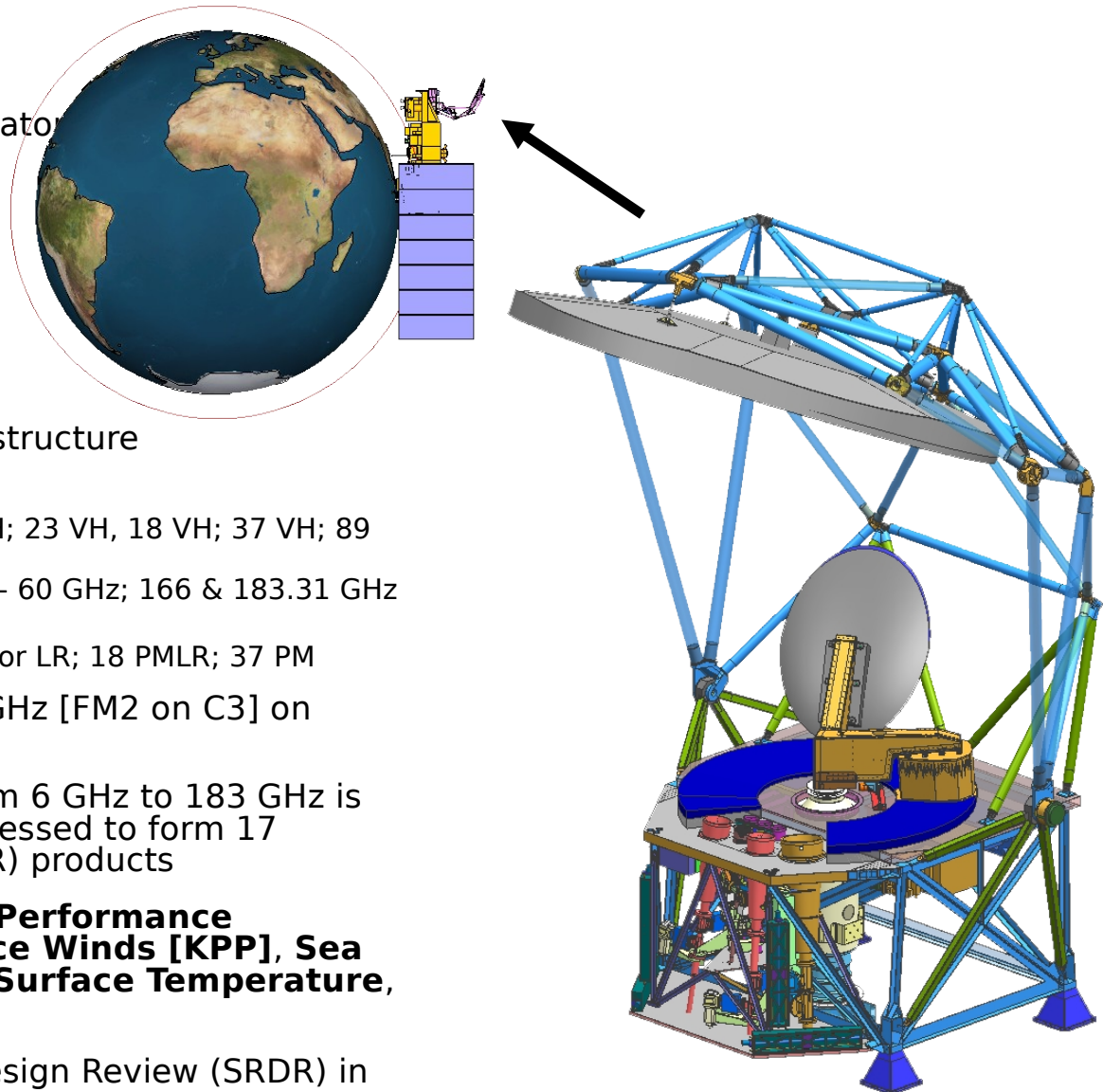


# Agenda

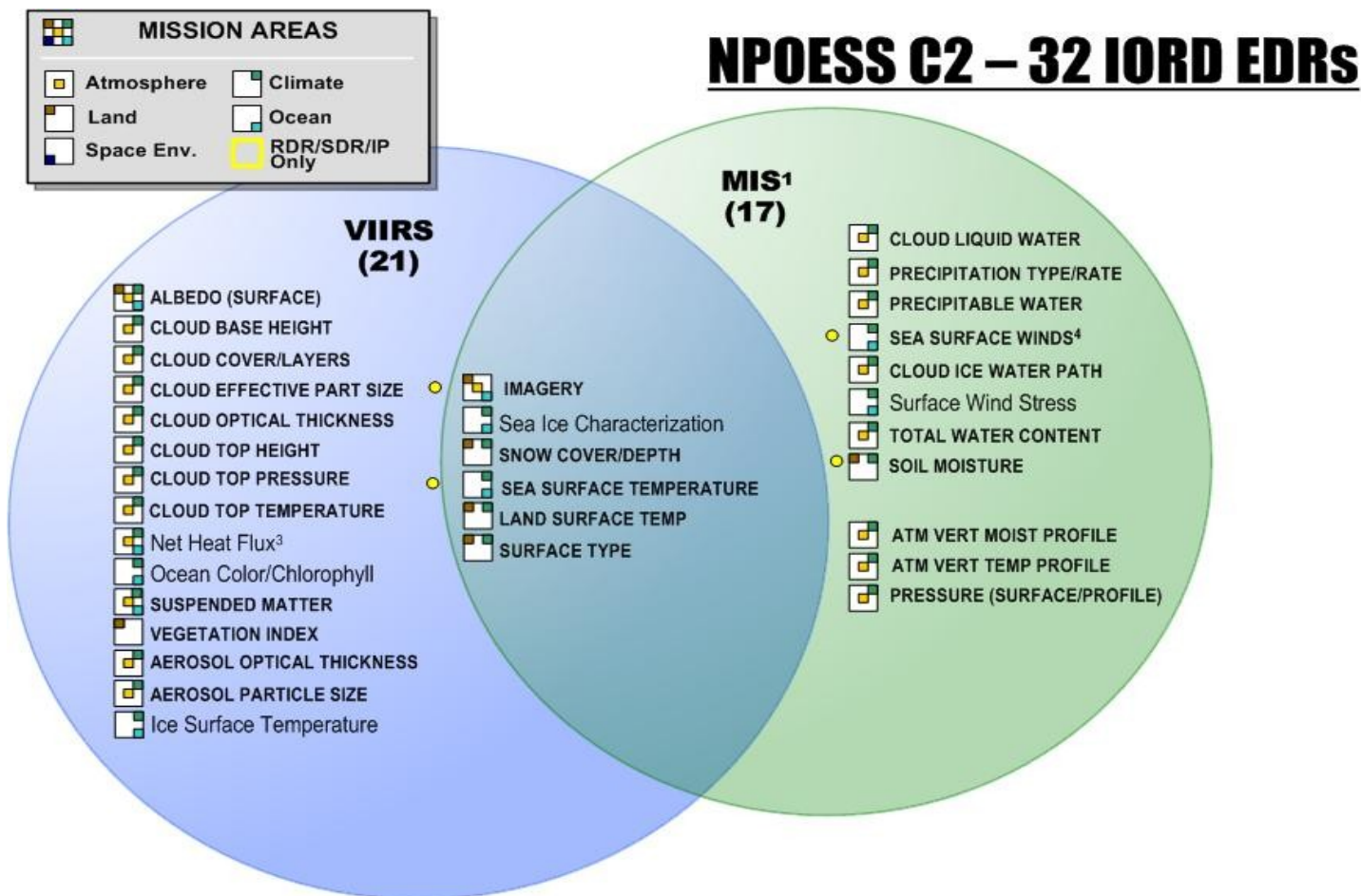
- What is MIS?
- EDR Products
- Trade Space and Baseline
- MIS vs. Legacy
- Typhoon Warning-related EDRs
  - Sea Surface Winds
  - Sea Surface Temperature
  - Cloud Liquid Water, Precipitable Water
  - Precipitation Rate
  - Imagery
- Summary

# What is MIS?

- MIS is a GFE sensor, developed by the Naval Research Laboratory
- MIS FM1 on NPOESS C2
  - Launch date May 2016
    - (Current Best Estimate)
  - 17:30 orbit, 828 km
- **Conical scanning at 31.6 rpm**
- **Swath Width: ~1,700km**
- 1.8m main reflector deployable structure
- 39 Channels; 12 feedhorns
  - **Core Imaging Channels:** 10 VH; 23 VH, 18 VH; 37 VH; 89 VH
  - **Atmospheric Sounding:** 50.3 – 60 GHz; 166 & 183.31 GHz
  - Low Frequency: 6.8 VH
  - **Polarimetric Channels:** 10 PM or LR; 18 PMLR; 37 PM
- **Upper Air Sounding:** 60 – 63 GHz [FM2 on C3] on going trade study
- Upwelling Microwave energy from 6 GHz to 183 GHz is detected by the sensor and processed to form 17 Environmental Data Record (EDR) products
- Key EDRs: **Soil Moisture [Key Performance Parameter (KPP)], Sea Surface Winds [KPP], Sea Surface Wind Direction, Sea Surface Temperature, Imagery**
- Sensor System Requirements Design Review (SRDR) in May 2009



# MIS EDRs (NPOESS C2)



## KEY

● = EDRs with Key Performance Parameters  
BOLD CAPS = LRD Environmental Data Records

## NOTES:

1. EDR performance compliant with MIS TRD
2. N/A
3. Degraded by surface emissivity knowledge
4. Delivered as two MIS products – Speed (Key EDR) and Direction

EDRs not delivered by NPOESS are not counted in totals  
Each sensor produces a unique product in overlap regions

03 March 2009

DoD, NOAA, NASA,  
Integrated Program Office  
M. Haas, F. Eastman  
G. Mineart, J. Whitcomb

C2  
V17



# MIS Trade Space

	Existing Systems								MIS Concepts												Reference			
	SSMIS		AMSR-E		TMI		WindSat		A		A-1		A-2		B		B-1		B-2		B-8		CMIS	
EDR (IORD II Thresholds)	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS
Atm Vertical Moisture Profile			No Sounding		No Sounding		No Sounding		No Sounding		No Sounding				No Sounding		No Sounding							
LA Atm Vertical Temperature Profile	APU	HCS	No Sounding		No Sounding		No Sounding		No Sounding		No Sounding				No Sounding		No Sounding							
UA Atm Vertical Temperature Profile			No Sounding		No Sounding		No Sounding		No Sounding		No Sounding		No UAS		No Sounding		No Sounding		No UAS		APU	HCS	APU	HCS
Imagery																								
Sea Surface Temperature	No 6/10 GHz		APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS
Sea Surface Wind Speed	APU	HCS		HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS
Sea Surface Wind Direction (< 7m/s ws)	No Polarimetric Channels								No P Channels						No P Channels									
Sea Surface Wind Direction (>= 7m/s ws)	No Polarimetric Channels						APU	HCS	No P Channels		APU	HCS	APU	HCS	No P Channels		APU	HCS	APU	HCS	APU	HCS	APU	HCS
Soil Moisture	APU	HCS			APU	HCS																		
Precipitable Water																								
Precipitation Type/Rate*	APU*	HCS	APU*	HCS	APU*	HCS	APU*	HCS	APU*	HCS	APU*	HCS	APU*	HCS	APU*	HCS	APU*	HCS	APU*	HCS	APU*	HCS	APU*	HCS
Pressure (Surface/Profile)			No Sounding		No Sounding		No Sounding		No Sounding		No Sounding		APU	HCS	No Sounding		No Sounding							
Total Water Content			No Sounding		No Sounding		No Sounding		No Sounding		No Sounding		APU	HCS	No Sounding		No Sounding		APU	HCS	APU	HCS	APU	HCS
Cloud Base Height**	**		No Sounding		No Sounding		No Sounding		No Sounding		No Sounding		**		No Sounding		No Sounding		**		**		**	
Cloud Ice Water Path			No Sounding		No Sounding		No Sounding		No Sounding		No Sounding				No Sounding		No Sounding		APU	HCS	APU	HCS	APU	HCS
Cloud Liquid Water (Ocean)																								
Snow Cover/Depth	APU	HCS	APU	HCS	No Data		APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS
Ice Surface Temperature					No Data																			
Sea Ice Characterization					No Data																			
Surface Wind Stress							APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS	APU	HCS
Legacy EDR Swath Width @ 828 km Altitude	1700		1450		1400		1200		~1700		~1700		~1700		~1700		~1700		~1700		~1700		1700	
* Precipitation is highly variable and cannot be validated (Dr R. Spencer @ MOAT)																								
** Algorithm has not been developed																								

## W/R/T IORD-II

No Capability
Useful Data/Marginal
Min IORD Capability
IORD or Better
Unknown

A: 1.2 meter Antenna

B: 1.8 meter Ant. + 6 GHz

x1: Core Imaging + Polarimetry

x2: Core + Polarimetry + Sounding

B8: 1 + 2 + Upper Air Sounding



# MIS System Spec Baseline

	Existing Systems				MIS Concepts										Reference	
	SSMIS	AMSR-E	TMI	WindSat	A	A-1	A-2	B	B-1	B-2	B-8	CMIS				
EDR (IORD II Thresholds)	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS
Atm Vertical Moisture Profile		No Sounding	No Sounding	No Sounding	No Sounding	No Sounding		No Sounding	No Sounding							
LA Atm Vertical Temperature Profile	APU   HCS	No Sounding	No Sounding	No Sounding	No Sounding	No Sounding		No Sounding	No Sounding							
UA Atm Vertical Temperature Profile		No Sounding	No Sounding	No Sounding	No Sounding	No Sounding	No UAS	No Sounding	No Sounding	No UAS						
Imagery																
Sea Surface Temperature	No 6/10 GHz	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS
Sea Surface Wind Speed	APU   HCS	HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS
Sea Surface Wind Direction (< 7m/s WS)	No Polarimetric Channels				No P Channels			No P Channels								
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Soil Moisture	APU   HCS		APU   HCS													
Precipitable Water																
Precipitation Type/Rate*	APU*   HCS	APU*   HCS	APU*   HCS	APU*   HCS	APU*   HCS	APU*   HCS	APU*   HCS	APU*   HCS	APU*   HCS	APU*   HCS	APU*   HCS	APU*   HCS	APU*   HCS	APU*   HCS	APU*   HCS	APU*   HCS
Pressure (Surface/Profile)		No Sounding	No Sounding	No Sounding	No Sounding	No Sounding	APU   HCS	No Sounding	No Sounding	No Sounding	No Sounding	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS
Total Water Content		No Sounding	No Sounding	No Sounding	No Sounding	No Sounding	APU   HCS	No Sounding	No Sounding	No Sounding	No Sounding	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS
Cloud Base Height**	**	No Sounding	No Sounding	No Sounding	No Sounding	No Sounding	**	No Sounding	No Sounding	No Sounding	No Sounding	**	**	**	**	**
Cloud Ice Water Path		No Sounding	No Sounding	No Sounding	No Sounding	No Sounding		No Sounding	No Sounding	No Sounding	No Sounding	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS
Cloud Liquid Water (Ocean)																
Snow Cover/Depth	APU   HCS	APU   HCS	No Data	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS
Ice Surface Temperature			No Data													
Sea Ice Characterization			No Data													
Surface Wind Stress				APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS	APU   HCS
Legacy EDR Swath Width @ 828 km Altitude	1700	1450	1400	1200	~1700	~1700	~1700	~1700	~1700	~1700	~1700	~1700	~1700	~1700	1700	1700

**A, A-1, A-2 Provides Inadequate Spatial Resolution for IORD-II**

**B-2 Equals or Surpasses Legacy Performance (no UAS)**

## W/R/T IORD-II

No Capability
Useful Data/Marginal
Min IORD Capability
IORD or Better
Unknown

**A: 1.2 meter Antenna**

**B: 1.8 meter Ant. + 6 GHz**

**x1: Core Imaging + Polarimetry**  
**x2: Core + Polarimetry + Sounding**  
**B8: 1 + 2 + Upper Air Sounding**

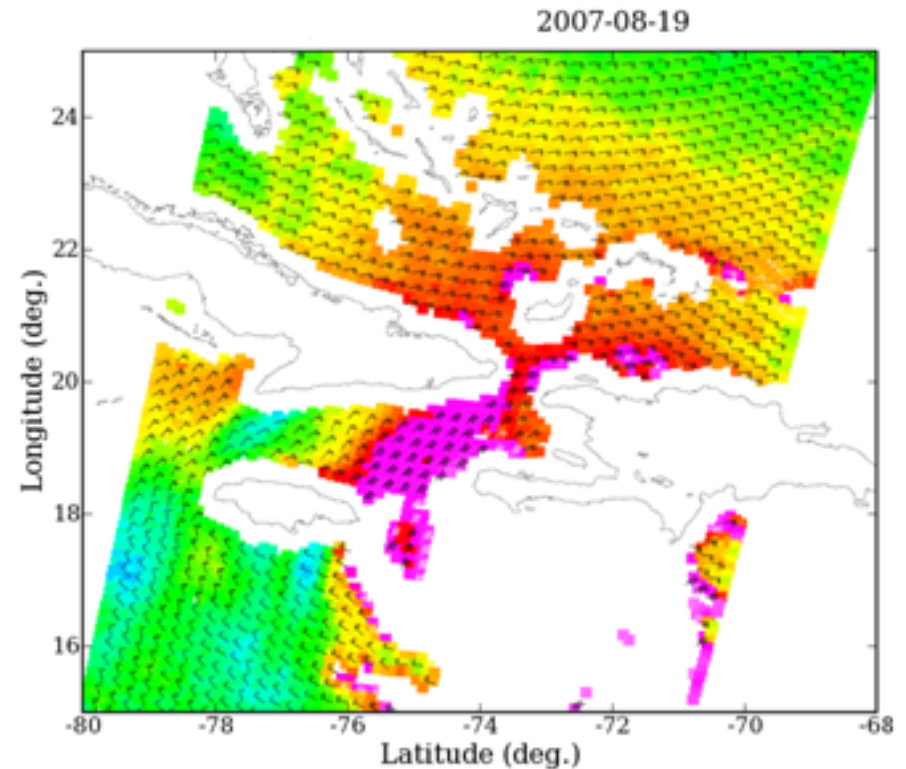


# MIS vs. Legacy

EDRs	Cell Size	Measurement Range	APU	Conditions	Improvements
Integrated Water	58 → 25 km	0–80 mm	10% or 2mm (U)		Resolution
Wind Speed	58 → 30 km	0–25 m/s	1.4 m/s (P)	No rain unbinned	Resolution
Wind Direction	~45 km	>6 m/s	<30° (P)		New (WindSat)
SST (All Weather)	60 km	271–307 K	<1 K (U)		New (AMSR-E)
Soil Moisture	60 km	0–50%+	10% (U)	<1/5 kg/m <sup>2</sup> Cover	New (AMSR-E)
Snow (WE)	58 → 25 km	0–25 cm	3 cm (P)		Resolution
Sea Ice (Age) (Concentration)	58 → 25 km	Multi-Year/New 0-100%	20% (U) 10% (U)		Resolution

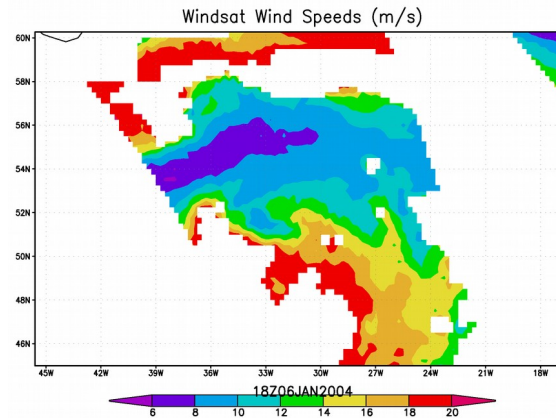
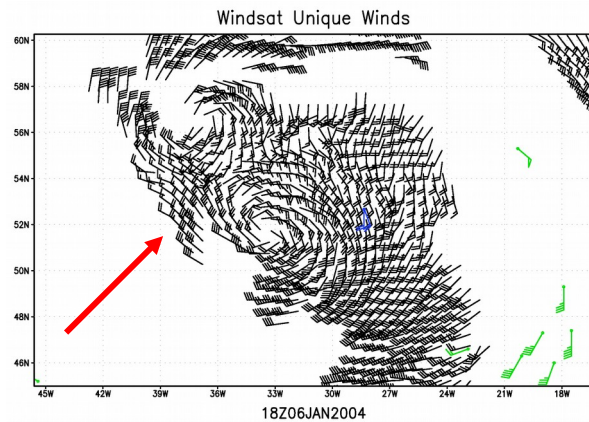
# Sea Surface Winds

- MIS expected to produce sea surface wind vectors similar to on-orbit capability of WindSat
- Wind direction capability has shown significant utility for improving typhoon forecasts
- UK Met office is now assimilating WindSat data into their Global Model
  - Demonstrated positive impact on Forecasting Tropical Cyclone tracks



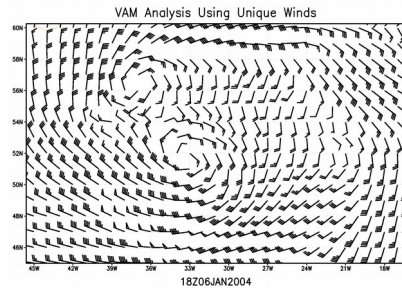
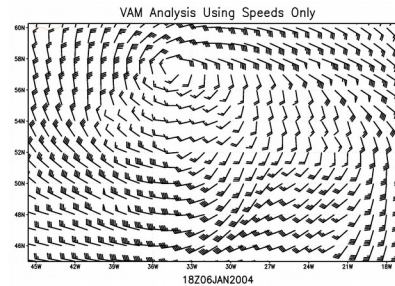
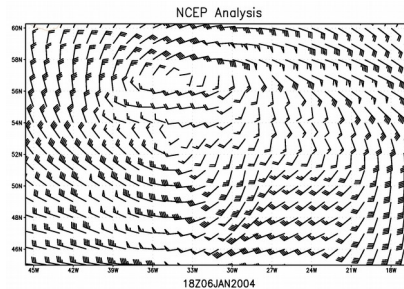
***Wind direction retrievals using WindSat data in the Caribbean, 19 Aug 07***

# WindSat Data Comparison

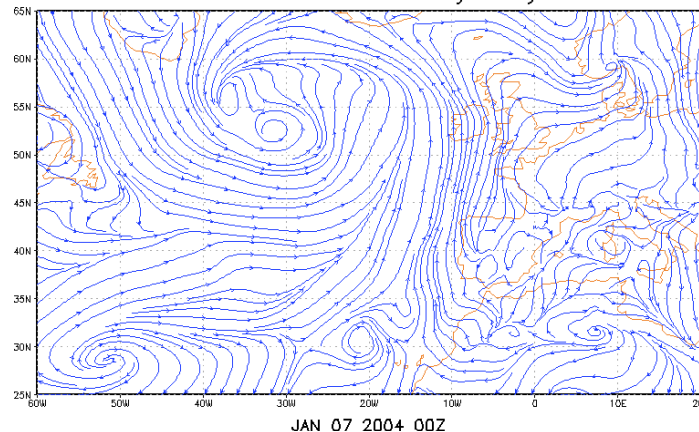


**WindSat Data Comparison  
with NCEP Forecast Model  
Showing Detection**  
(Analysis by R. Atlas, NOAA  
AMOL, Ocean Sciences  
Conference, February 2006).

NCEP analysis  
January 6



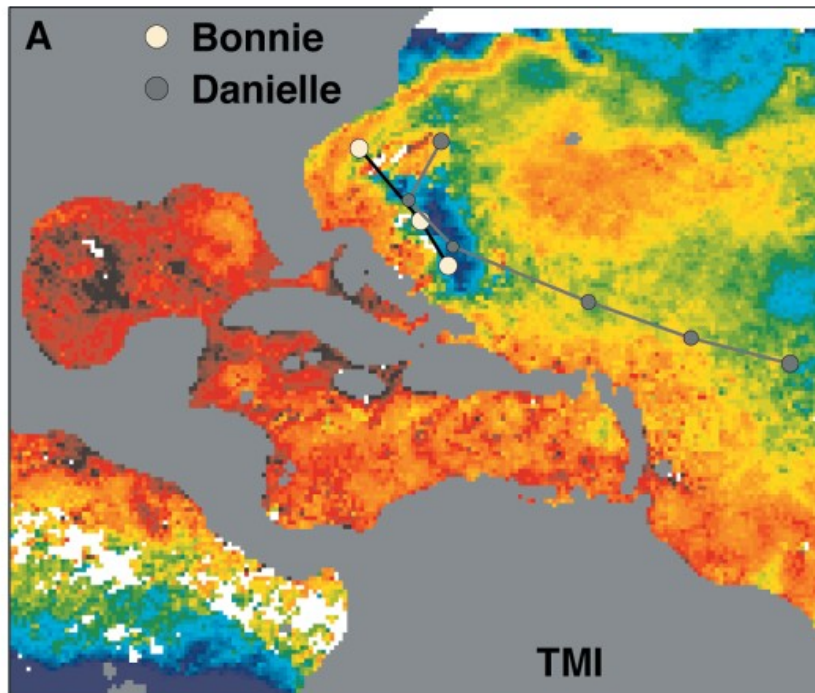
the two vortices are now analysed by NCEP



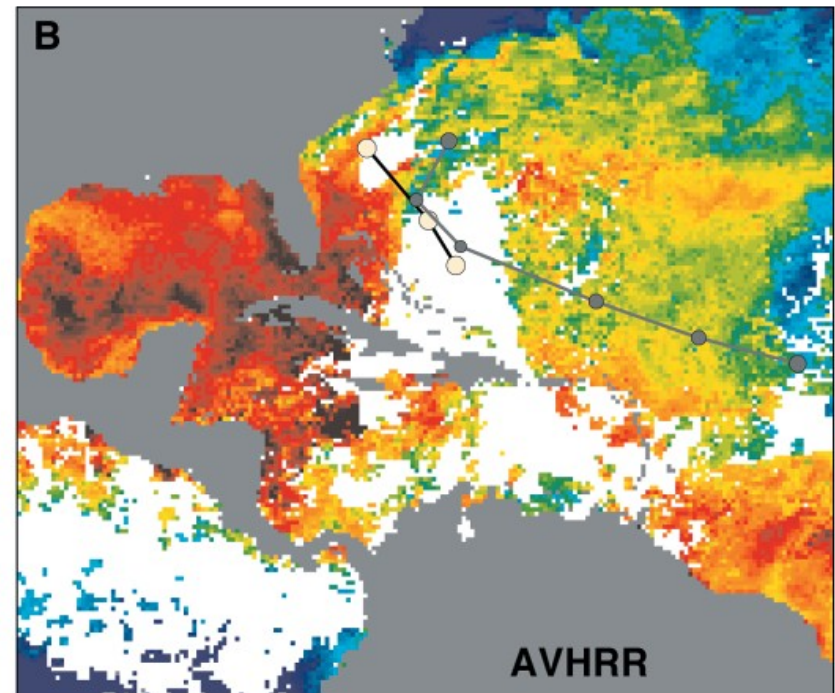
NCEP analysis  
January 7

**WindSat Surface Wind retrievals  
in the North Atlantic show the  
presence  
of paired cyclonic vortices not  
captured  
until the following day by the  
National  
Center for Environmental**

# Sea Surface Temperature



[LEFT] A cold wake (blue region near the white circles) was produced by Hurricane Bonnie on 24 to 26 August 1998, as seen by the TRMM Microwave Imager (TMI)



[RIGHT] The cold wake was not seen by the visible/infrared AVHRR imager (right) due to areas of persistent rain and cloud cover (white patches) over the 3-day period.

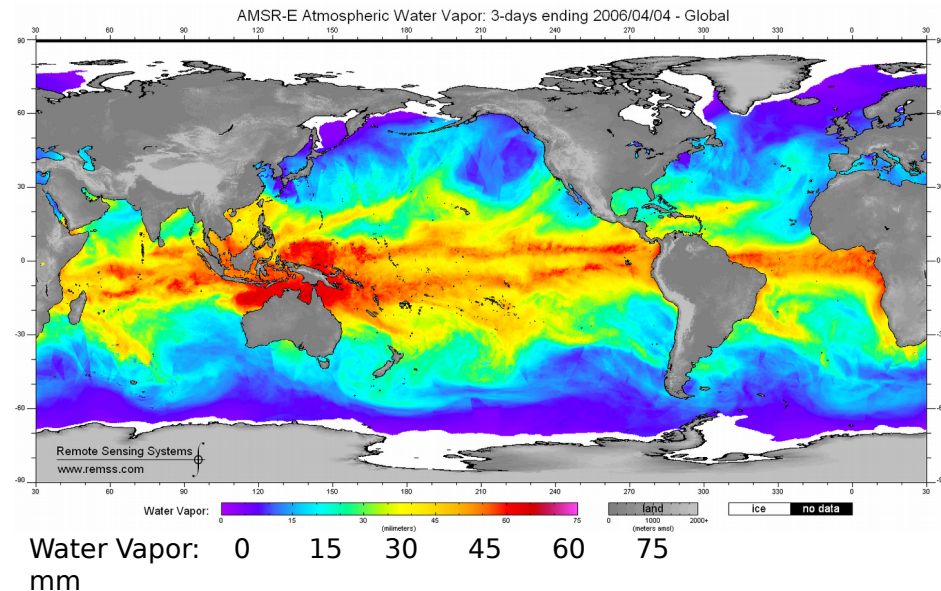
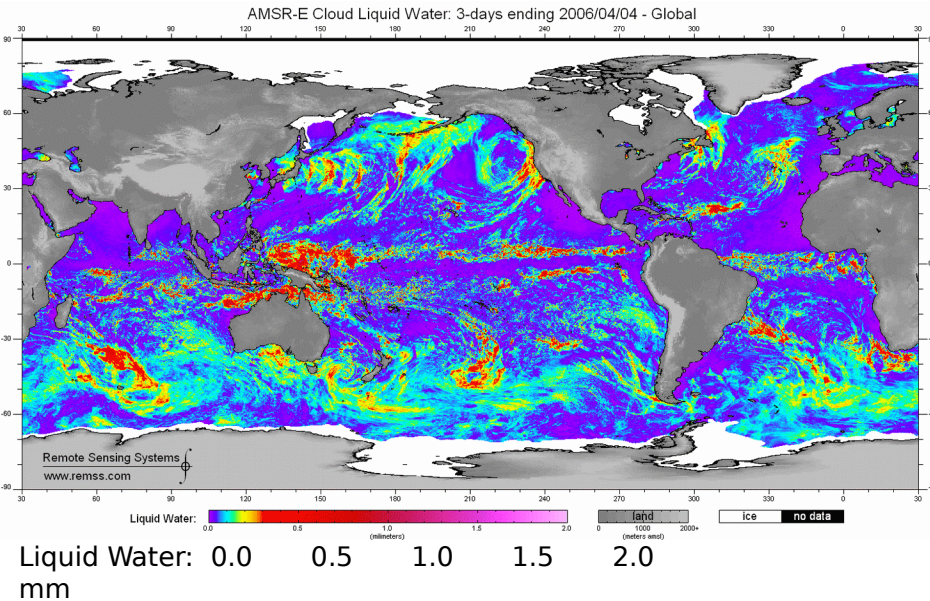
White dots: Hurricane Bonnie's daily position as it moved northwest from 24 through 26 August.

Gray dots: Hurricane Danielle as it moved northwest from 27 August through 1 September.

Danielle crossed Bonnie's cold wake on 29 August and its intensity dropped. Cloud cover prevented AVHRR from observing this sequence, however, TMI was able to

# Cloud Liquid Water and Precipitable Water

MSR-E Cloud Liquid Water: 3-days ending 20060404 Atmospheric Water Vapor: 3-days ending 20060404



Global maps of total Precipitable Water and Cloud Liquid Water are produced from AMSR-E data on the Aqua satellite and from SSM/I and SSMIS on DMSP.

These datasets have value for weather forecasts and models of the energy and water cycles.

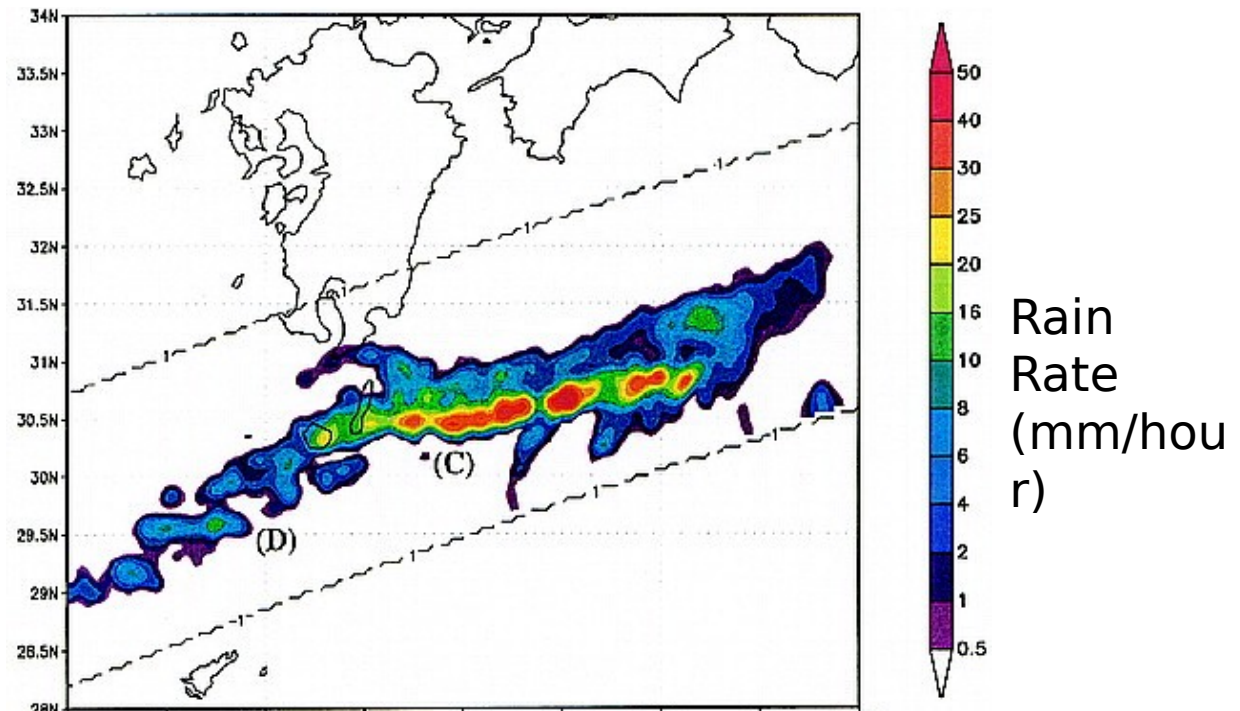
Precipitable Water Vapor is considered critical for data continuity for GEOSS.

Only microwave sensors can provide estimates of Cloud Liquid Water.

MIS provides same performance as AMSR-E.

# Precipitation Rate

**Rain rate (mm/h)  
at 2 km height  
from TMI. Squall  
line south of Japan.  
(From Aonashi and  
Liu, JAM, 2000).**

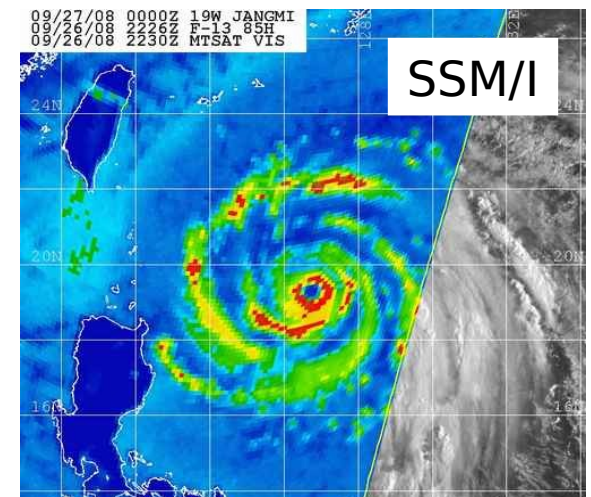
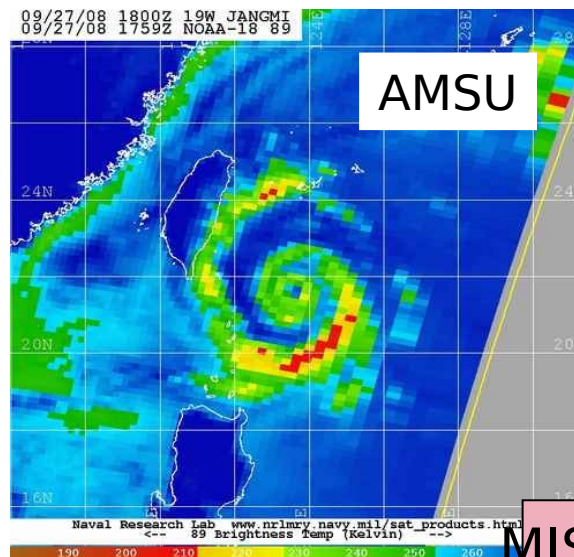
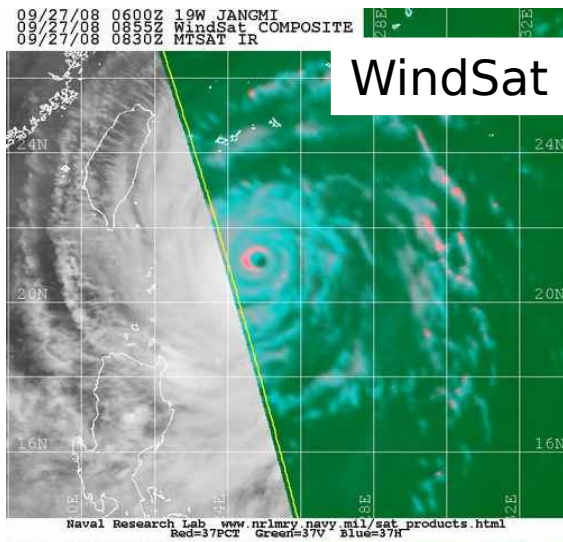


**Measurements of precipitation rate are valuable for tactical maneuvers, maritime navigation, and fisheries dynamics, and supports climate studies.**

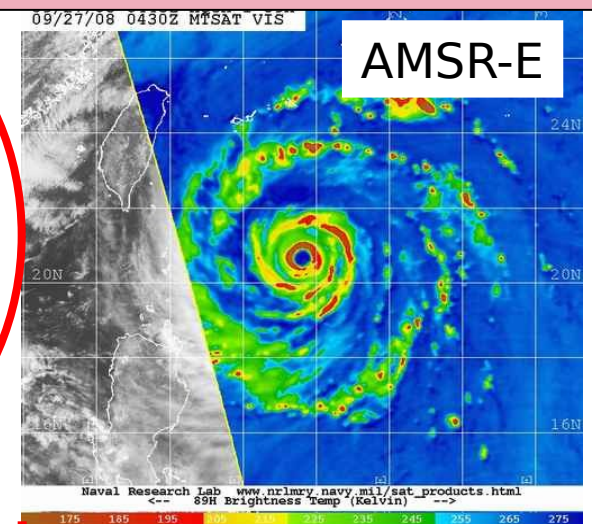
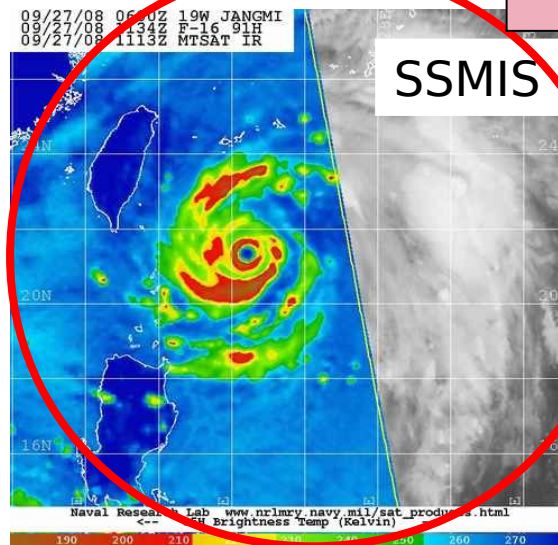
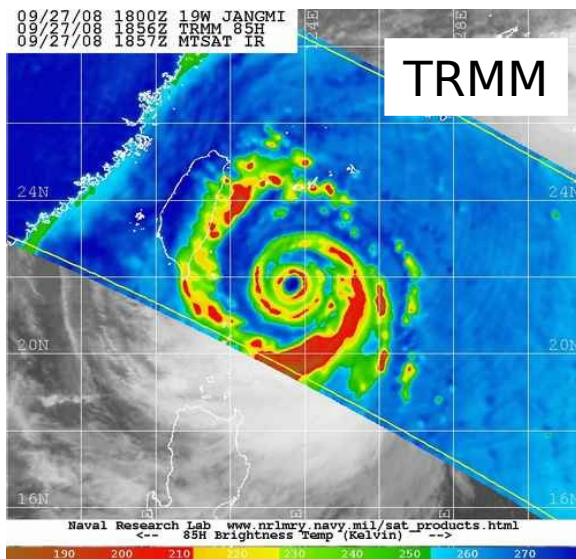
**MIS will provide global rain rate measurements.**



# Imagery



MIS Imagery HCS will closely resemble SSMIS





# Summary

- NPOESS MIS development continues to represent the latest most capable operational microwave radiometer
  - MIS is responsible for 17 EDRs (includes 2 NPOESS KPPs)
  - MIS offers improvements to nearly all legacy EDRs:
    - DMSP SSMIS: Better horizontal spatial resolution
    - NASA AMSR-E: RFI mitigation for 6 GHz
    - NRL WindSat: Similar wind direction capability
  - Improvements to weather forecasts are expected from MIS atmospheric sounding, wind direction, and all weather sea surface temperature capabilities